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Creation of heat-resistant, high-product breeds and hybrids of mulberry silkworm (*Bombyx mori l.*)

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Abstract. In the current era of highly developed science, technology and technology, the demand for natural fabrics is increasing year by year in the world market, and the world silk industry and science are led to the cultivation of mulberry varieties with high nutritional value and the creation of breeds and hybrids suitable for different seasons of the changing external environment. In recent years, in the Republic of Uzbekistan, the practice of rearing mulberry silkworms several times a year has been used. However, there are no breeds and hybrids suitable for the hot summer conditions of our country, based on this, scientific research has been started in the direction of creating heat-resistant breeds at the Silk Research Institute. In this article, the results of the breeding of 6 breeds and 4 different industrial hybrids of mulberry silkworm under hot conditions are described. Based on preliminary data, Line 1 and Line 2 systems were found to have high embryonic and post-embryonic viability under hot summer conditions. However, the average cocoon weight of these systems was 1.68-1.73 g, cocoon shell weight was 339 mg, and cocoon silkiness was 19.6-20.2%. Based on the obtained results, it was concluded that Line 1 and Line 2 systems can be used as initial selection material for creating heat resistant breeds.

1 Introduction

Throughout the history of civilization, mankind has been constantly searching for the preparation and rational use of food, clothing and household items for its needs, especially its demand for natural fibers and fabrics has been very high [1-4].

In the current era of highly developed science, technology and technology, the demand for natural fabrics is increasing year by year in the world market, and the world silk industry and science are led to the cultivation of mulberry varieties with high nutritional value and the creation of breeds and hybrids suitable for different seasons of the changing external environment [5-7]. In this direction, cultivation of new generation super elite, elite

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and industrial eggs of mulberry silkworm using scientifically based methods of selection and breeding of mulberry silkworm is one of the most urgent scientific problems [1-3].

The main attention of the scientists and specialists of countries with developed sericulture science is focused on the preparation of high-quality cocoon raw materials, as well as obtaining a high cocoon yield from mulberry silkworms that are cared for in different seasons [6-9]. In this regard, in the summer and autumn seasons in the People's Republic of China, 65-70 kg of live cocoon raw material can be obtained from 1 box of seeds, 60-67 kg in India, and 40-45 kg in Uzbekistan. Increasing this indicator and improving the quality of the cocoon raw material is one of the urgent tasks of today [5, 10].

Special attention is being paid to scientific research on the creation of new selection methods and innovative developments aimed at creating varieties and breeds resistant to global changes in the world climate, plant and animal world changes in the external environment. In this regard, as part of the research carried out in our country, in order to reduce the impact of negative environmental factors on the biological and technological indicators of mulberry silkworm suitable for repeated worm feeding, using other species as donors to Bombyx mori L., maintaining the quality indicators of silk fiber in changing natural climate conditions, and external environmental factors [8-10]. It is important to carry out scientific research on the creation of new breeds and hybrids by studying the factors that lead to a decrease in the vitality, viability, disease resistance level, cocoon productivity and the technological indicators of silk fiber, which are considered very important for industrial enterprises, of highly sensitive mulberry silkworms.

In this scientific direction, interesting works have been carried out by a number of foreign and local scientists, in the researches of Azerbaijanis [2], how the environmental conditions of the regions affect the biological characteristics of worms have been studied, in the experiments conducted by [3] in the care of silkworm breeds of bivoltine Bombyx mori L. the direct effect of high temperature and high humidity on silkworms has been scientifically proven.

The leading breeders [4] and [5] have scientifically substantiated the effect of reproductive, viability and cocoon productivity and environmental factors on the physical and mechanical properties of cocoon fiber of the hybrids selected for the summer and autumn seasons in different regions of Uzbekistan.Also, [6] and [8] studied the influence of external environmental factors on the second generation (F2) cocoon productivity of silkworm care in adverse natural climatic conditions and the morphological and technological parameters of imported mulberry silkworm hybrids, [7] mulberry new selection No. 2 In addition to researching the morphological characteristics of selection numbers -02, #3-02, #4-02, #5-02 and #7-02, they also evaluated their effect on silkworm larvae.

It should be noted that [9] carried out research on the dependence of external environmental factors on changes in productivity and reproductive performance of silkworms.

In the process of building a new Uzbekistan, important measures are being taken in such directions as increasing the quality and volume of cocoon raw materials, creating a new generation of mulberry silkworm breeds and hybrids suitable for the spring and summer seasons, and improving the technological properties of cocoon and silk raw materials obtained from them. "Extensive testing of breeding achievements, development of primary seed production of mulberry silkworm breeds and hybrids, mulberry hybrids, taking into account the natural climatic conditions of the regions, introduction of scientific developments and intensive agro-technologies into production"1 is defined as the main tasks. In this regard, research of new agrotechnologies aimed at improving the quality and technological characteristics of cocoons grown using the flexibility and endurance potential of this breed and hybrids in different ecological regions due to the influence of ecological factors on biological, cocoon productivity and technological characteristics of industrial hybrids of mulberry silkworm suitable for different seasons and it is desirable to expand the scope of scientific research on the development of high-quality silk raw materials [1-5].

Decree No. PQ-3616 of the President of the Republic of Uzbekistan dated March 20, 2018 "On additional measures to further develop the cocoon industry" and No. PQ-4567 dated January 17, 2020 "On additional measures to develop the silkworm feed base in the cocoon industry" specific tasks regarding the widespread introduction of new innovative developments in science and production processes have been defined in the decisions.

Based on the above, creation of new monovoltine breeds resistant to repeated worm feeding in the hot summer and autumn seasons of our country and hybrids with their participation and their implementation is a scientific and practical direction. From this point of view, it is important to create new breeds and hybrids on the basis of conducting selection work in the population of breeds adapted to the specific natural climatic conditions of our republic [6-9]. Since there are no bivoltine (twice a year) and polyvoltine (gives 5-6 times a year) breeds of mulberry silkworm resistant to harsh continental climatic conditions in our country, within the framework of practical projects, in the population of monovoltine breeds, resistant to hot temperatures and dry conditions in the sharply changing conditions of spring and summer, genetic and genotypes that preserve the genetic potential to the maximum are selected, and several breeding generations are obtained based on them [8,9]. Based on the families selected as a result of research, heat-resistant high-yielding breeds and hybrids are created. Breeds created at the end of scientific researches lead to a sharp increase in cocoon productivity and cocoon quality during repeated worm feeding in our country.

The purpose of the research work is to study the reaction of mulberry silkworm genotypes to the extreme factors of summer and autumn seasons and to identify, select and create new breeds of the most heat-resistant genotypes [2-5].

2 Materials and methods

Creation of breeds and hybrids of mulberry silkworms resistant to hot climate conditions Line 1, Line 2, Line 15, Line 16 breeding systems created in the laboratory of "Breeding, Ecology and Prevention of Chemical Poisoning of Mulberry Silkworms" of the Research Institute of Sericulture were maintained in special worm houses in optimal hygrothermal conditions. . The eggs of the experimental breed and hybrid populations were revived in a special incubation, and the larvae were nurtured with mulberry leaves in the mulberry plantations of the unitary enterprise "Mulberry Experimental Farm" [3-6].

The following methods were used in the implementation of planned experiments in our research work. The method of creating and breeding breeds of mulberry silkworm resistant to hot climate conditions has not been studied. Therefore, research aimed at developing the most useful selection methods for the creation of heat-resistant breeds should be carried out a little earlier, and then directly [4-6]. During the first methodological research, the study of the presence of heat resistance properties of worms. Preliminary studies to investigate the existence of heat-resistant families within the same breed.

Scientific research initially began during the spring worm feeding season of 2022. In this case, the heat-resistant ones were separated from the families of the pure breeds according to the viability of the eggs [1-5]. Developmental characteristics of heat-tolerant worms were monitored as a result of the care of revived worms. The cocoons of the breeds and selection systems that are resistant to hot climate conditions were picked and economically important (worm viability, cocoon productivity and technological) indicators were individually analyzed and selected [4-6, 10]. Egg casts were prepared for the next generation from heat-resistant and hatchable butterflies. In the experiment, F1 generations were separated from egg casts prepared by crossing heat-resistant breeds and systems, and selection was carried out according to the above characteristics [8-10]. The data obtained for each breed and system were compared with the reference purebred population and foreign breeds. The obtained data were analyzed by methods of biological statistics.

3 Results and discussion

Embryonic and post-embryonic viability of selection material, especially heat resistance is the main indicator in selection. Chemical and hot temperature effects on eggs make it possible to select egg casts from breeding families that survive well even under extreme conditions. Worms' viability can be sharply reduced directly due to high temperature and poor quality feed. The selection of genotypes that survive in such conditions can be the basis for the creation of heat-tolerant breeds. According to the above considerations, in the experiments, egg survival, worm viability and disease percentage, i.e. the percentage of deaf cocoons, were prioritized as the main selection characters. Table 1 shows the indicators of embryonic and postembryonic viability of breeding systems.

Table 1. Viability of Summer Worm Feeding Systems (July-August 2022)

Systems and hybrids	Number of analyzed families	Revival of eggs, %			Viability of worms, %			Incidence rate, %			P,%
		$\bar{X}$pop	$\bar{X}$bod	S(sel.dif.)	$\bar{X}$pop	$\bar{X}$bod	S(sel.dif.)	$\bar{X}$pop	$\bar{X}$bod	S(sel.dif.)	
Line 1	30/21	* 87.1±3.0	95.8	8.7	* 89.6±1.10	93.1	3.5	* 2.09±0.24	1.72	-0.37	66.7/50.0
Line 2	38/21	* 84.5±2.7	95.0	10.5	* 89.1±1.52	94.2	5.1	* 3.9±0.78	2.1	-1.8	63.2/52.4
Line 15	16/11	* 59.1±5.3	66.2	7.1	* 87.0±1.39	88.7	1.7	* 1.9±0.22	1.75	-0.16	62.5/81.8
Line 16	16/12	* 64.7±5.8	79.7	15.0	* 89.0±1.21	91.6	2.6	* 3.6±0.70	2.7	-0.09	62.5/58.3
Marvarid (control)	16	83.0±2.6	-	-	78.0±2.27	-	-	6.7±0.60	-	-	-

Guzal (control)	16	56.6±5.1	-	-	88.4±1.28	-	-	3.6±0.84	-	-	-
Line 1 x Line 2	3	** 90.6±1.45	-	-	** 92.7±0.13	-	-	** 2.6±0.24	-	-	-
Line 2 x Line 1	3	** 92.3±1.45	-	-	** 91.1±2.78			** 2.6±1.2	-	-	-
Line 15 x Line 16	16	** 92.2±60.5	-	-	** 93.3±2.36			** 1.16±0.23	-	-	-
Line 16 x Line 15	3	** 93.6±1.45	-	-	** 91.4±2.17			** 2.02±1.49	-	-	-
Foreign hybrids	3	76.3±3.2	-	-	85.5±1.16			2.19±0.43	-	-	-
*Pd= 0,236-0,999 ** Pd= 0,076-0,999											

Analyzing the data of Table 1, an active difference in egg survival of breeding systems is noticeable. This indicator was 84.5-87.1% in Line 1 and Line 2 systems, while it was much lower in Line 15 and Line 16 systems - 59.1% and 64.7%. Egg survival in Marvarid and Gozal breeds, taken for control, was equal to 83.0% and 56.6%, respectively.

As for the worm viability indicator, the Line 1 (89.6 %) and Line 2 (89.1 %) systems showed high viability in hot conditions. In this regard, the performance of Line 15 and Line 16 systems is not too bad - 87.0-89.0%. In the control breeds, this number was in the range of 78.0-88.4% and showed a much lower result than Line 1 and Line 2.

Worm incidence at the end of the 5th instar and pupation period ranged from 1.9% to 3.6% in our four different breeding systems and increased to 6.7% in the control breeds.

Based on the analysis of all viability indicators, it can be said that the heat resistance feature is higher in Line 1 and Line 2 systems. These systems survived almost 87% despite abnormally hot outdoor temperatures, and under these conditions nearly 90.0% of worms were saved and cocooning was achieved. These indicators are certainly an important factor in increasing the heat resistance of breeding systems and are the basis for carrying out selective selection in the next generations.

Embryonic and post-embryonic viability are considered as the most important indicators in the research aimed at creating heat-adapted breeds and hybrids, and cocoon productivity is also the most necessary indicator. In hot conditions, if the number of heads of the breed and hybrid is kept to a maximum, but the cocoon weight does not reach 1.0 grams, the intended breed cannot be obtained from such selection material. Therefore, at the next stage, we determined the weight of cocoons maintained in the hottest conditions of summer and selected the best families from among the breeding systems, performing individual selections for cocoon weight, silk shell weight and silkiness indicators. The indicators obtained in July-August 2022 are placed in the histograms in Table 2 and Figures 1 and 2.

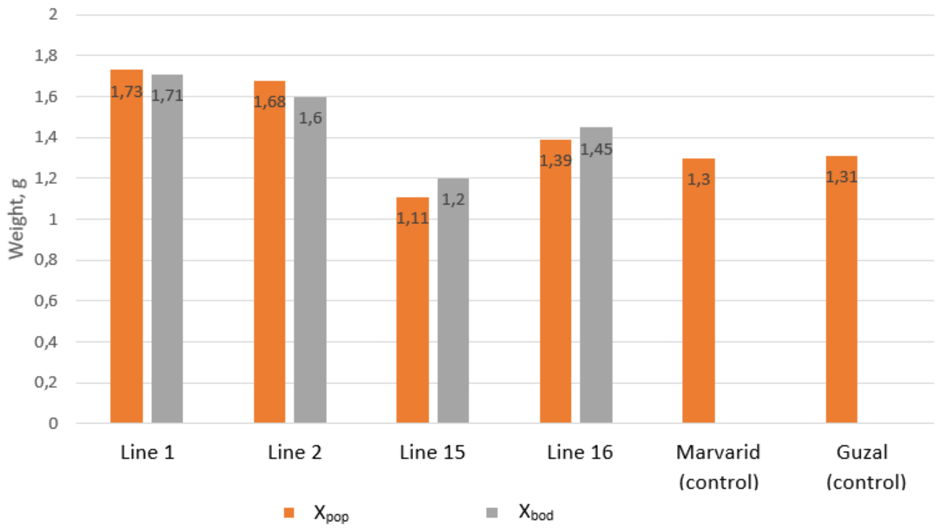

Fig. 1. Cocoon weight of silkworm systems maintained during the summer season (2022)

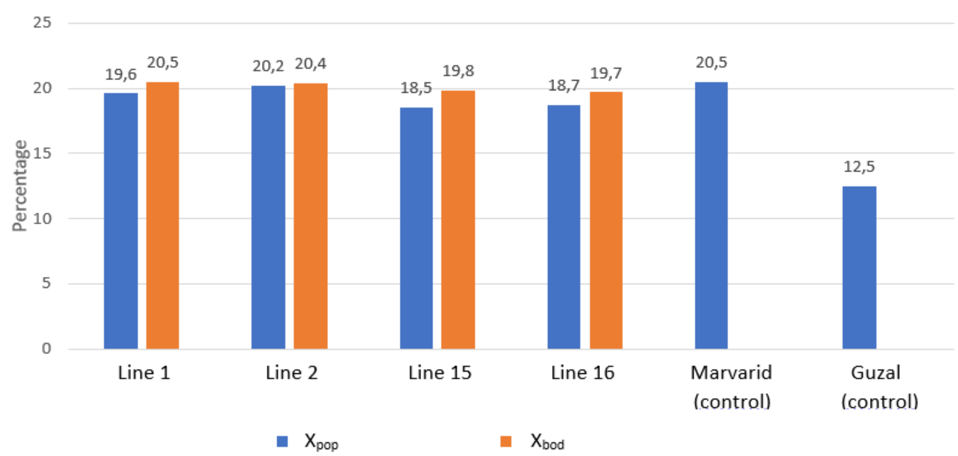

Fig. 2. Silkiness of summer reared silkworm systems (2022)

Table 2. Results of selection work on cocoon productivity in the summer season (July-August 2022)

Indicators		Line 1	Line 2	Line 15	Line 16	Marvarid (control)	Guzal (control)
Cocoon weight, g	Number of analyzed cocoons	609	659	571	591	90	90
	Number	490	464	359	185	-	-

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	of cocoons selected for breeding						
	Selection intensity, %	80.5	70.4	62.9	31.3	-	-
	$\overline{X}_{pop}$, g	1.73±0.12	1.68±0.037	1.11±0.004	1.39±0.033	1.30±0.05	1.31±0.043
	$\overline{X}_{bod}$, g	1.71	1.60	1.20	1.45		
	$S_{(sel.dif.)}$	-0.02	-0.08	0.09	0.06		
Cocoon weight, g	Number of analyzed cocoons	609	659	571	591		
	Number of cocoons selected for breeding	490	464	359	185		
	Selection intensity, %	80.5	70.4	62.9	31.3		
	$\overline{X}_{pop}$, mg	339±0.003	339±0.005	205±0.006	259±0.016	267±0.016	282±0.010
	$\overline{X}_{bod}$, mg	347.8	318.6	276.4	283.7		
	$S_{(sel.dif.)}$	8.8	-20.4	71.4	247		
Silkiness, %	Number of analyzed cocoons	609	659	571	591		
	Number of cocoons selected for breeding	490	464	359	185		
	Selection intensity, %	80.5	70.4	62.9	31.3		
	$\overline{X}_{pop}$, %	19.6±0.08	20.2±0.10	18.5±0.60	18.7±0.10	20.5±0.31	12.5±0.17
	$\overline{X}_{bod}$, %	20.5	20.4	19.8	19.7		
	$S_{(sel.dif.)}$	0.9	0.2	1.3	1.0		

Before discussing the numbers in Table 2, it should be emphasized that the cocoon weight indicator directly depends on how the mulberry silkworm is fed. Our goal is to consume leaves that are dry and have a reduced amount of nutrients in the summer season, and to select genotypes that are adapted to such conditions. Therefore, it is not possible to grow spring cocoons in the unique extreme conditions of worm farming in Uzbekistan. Nevertheless, we have to choose Line, which is adapted to feed that is very difficult to eat, as mentioned above, from among the 4 promising systems. This indicator is necessarily obtained from the new selection material in relation to the control breed. Now, if we directly analyze the numbers of Table 2, a total of 2430 cocoons were individually analyzed for 4 systems, and 1498 of the best cocoons were selected for breeding. The selection intensity was 31.3% to 80.5%. The highest value of cocoon weight determined for the populations was between 1.68-1.73 g in Line 1 and Line 2 systems. This indicator was significantly reduced in Line 15 and Line 16 systems (1.11-1.39 g). Although our control breeds have large cocoons, the average weight of 1 cocoon did not exceed 1.31 g.

Both Line 1 and Line 2 systems showed high potential in terms of cocoon weight – 339 mg. The silkiness index was also 19.6% and 20.2% in these systems respectively, better than expected for the summer season.

If we conclude the selection work on cocoon productivity in abnormally warm adverse conditions, out of 4 systems, Line 1 and Line 2 systems can be concluded as suitable for the summer season. However, in the following years, it is necessary to continue intensive selection work on these systems in the summer season.

The main goal of creating new breeds suitable for hot summer conditions is to obtain industrial hybrids with their participation. Therefore, we took 4 hybrid combinations with promising systems at the next stage and also tested them under extreme summer conditions. Table 3 shows the performance indicators of these hybrids.

Table 3. Cocoon productivity of hybrids (July-August, 2022)

Hybrids	Cocoon weight, g	Cocoon weight, mg	Silkiness, %
Line 1 x Line 2	1.62±0.14	310±0.0	19.1±0.0
Pd	0.998	0.999	0.999
Line 2 x Line 1	1.65±0.009	350±0.013	21.2±0.69
Pd	0.999	0.999	0.632
Line 15 x Line 16	1.64±0.026	337±0.013	20.6±0.66
Pd	0.999	0.999	0.080
Line 16 x Line 15	1.65±0.07	336±0.001	20.3±0.01
Pd	0.999	0.999	0.516
Foreign hybrids (control)	1.18±0.004	241±0.03	20.5±0.28

The obtained results in Table 3 show that the index of cocoon weight was 1.62-1.65 g in industrial hybrids with new systems, that is, almost the same, and this indicator was 1.18 g in the control foreign hybrid. The highest index of cocoon weight was determined in the Line 2 x Line 1 industrial hybrid (350 mg). If we compare this figure with the control hybrid, it can be seen that it differs by 109 mg. In terms of silkiness, the Line 2 x Line 1 hybrid showed a high index - 21.2%. It was found that the silkiness of the remaining hybrids and the foreign hybrid were almost close to each other (19.1-20.6%).

4 Conclusions

The breeds of silkworms that are used today are descended from wild silkworms that lived in the mild climate of China. Although silkworms have been domesticated for more than 5,000 years, different breeds and hybrids show varying levels of viability and productivity in different regions. Because of this, each genotype has a different response to stress factors of the external environment. In particular, it is important for the theory and practice of breeding to adapt breeds to the hot climatic conditions of Uzbekistan, especially to the dry conditions of summer, and to select strong genotypes from their population. In our research work, the above opinion was fully confirmed.

Among the selection systems with 4 different genotypes, Line 1 and Line 2 systems first showed heat tolerance in their first generation in terms of embryonic and postembryonic viability. In the creation of breeds resistant to hot conditions, viability is one of the first characteristics. At the same time, the cocoon productivity of these two systems was confirmed to be relatively positive according to the results of the first generation. For example, Gozal and Marvarid breeds of large cocoons, which have been taken for control and have been maintained for many years, could not show their performance in anomalous hot conditions. All these given details indicate that in our research work, promising selection systems for the hot summer season of our country were founded.

References

1. N.O. Rajabov, S.R. Umarov, B.U. Nasirillaev, K.P. Fozilova, Solid State Technology, **63(4),** 150-159 (2020)
2. D.M. Adigozalova, 8th BACSA international conference "Climate changes and chemicals-the new sericulture challenges" April 2nd – 7th (2017)
3. H. Singh, N.S. Kumar, Psyche: A Journal of Entomology 1-11 (2010). https://doi.org/10.55446/IJE.2021.361
4. Sh. Umarov, B. Nasirillaev, and A. Batirova, IOP Conf. Series: Earth and Environmental Science **1068** (2022)
5. N.O. Rajabov, S.R. Umarov, B.U. Nasirillaev, K.P. Fozilova, Solid State Technology **63,** 4 (2020)
6. M.K. Ahsan, S.M. Rahman, University Journal of Zoology **27** (2008)
7. K.K. Kumar, S.S. Naik, International Journal of Zoological Research **7**, 4 (2011)
8. U.M.M. Ghazy, International Journal of Industrial Entomology **25**, 2 (2012)
9. V.V. Adolkar, S.K. Raina, D.M. Kimbu, International Journal of Tropical Insect Science **27**, 1 (2007)
10. U.M.M. Ghazy, The Journal of Basic & Applied Zoology **67**, 1 (2014)